IEEE Std 334-1994
(Revision of IEEE Std 334-1974)

IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations

Sponsor

**Nuclear Power Engineering Committee
of the
IEEE Power Engineering Society**

Approved March 28, 1994

IEEE Standards Board

Abstract: Methods and requirements for qualifying continuous duty Class 1E motors for use in nuclear power generating stations are provided. The methods are used for qualifying motors, extending the qualification, and updating the qualification if the motor's design or specified service conditions are modified. The requirements include the principles, procedures, and methods of qualification as they relate to continuous duty Class 1E polyphase squirrel cage ac motors.
Keywords: Class 1E motors, harsh environment, mild environment, nuclear power generating station, qualification, seismic

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Introduction

(This introduction is not part of IEEE Std 334-1994, IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations.)

The basic requirements for qualifying Class 1E equipment for nuclear power generating stations are described in IEEE Std 323-1983, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations. It requires that the qualification of Class 1E electric equipment include the demonstration of the capability of the equipment, or the components thereof, to meet their performance specifications under normal environments and under those conditions that cause, and are caused by, the design events for the station. IEEE Std 334-1994 defines requirements that are adequate for qualifying Class 1E equipment located in all areas of the nuclear power generating station, including harsh and mild environmental areas. At this time, it appears that the seismic event is the only design basis event with potential for common cause failure in otherwise mild environments; however, other environmental service conditions may also be contributors.

This revised IEEE standard provides a strong continuity to IEEE Std 334-1974 while attempting to more fully define the procedures by which Class 1E motors can be qualified. It has been restructured so that the parentage of IEEE Std 323-1983 is more readily apparent. Furthermore, this standard has been clarified and simplified based on experience in using IEEE Std 334-1974.

The intent of this document is to provide guidance for the development of tests or analytical data that are adequate to demonstrate the capability of continuous duty Class 1E electric motors to perform their safety function. It discusses the qualification requirements of Class 1E electric motors and their service conditions pertinent to nuclear power generating stations. It gives guidelines to ensure uniformity in reporting data and to permit direct comparison of required and test values of all significant parameters.

This standard addresses continuous duty motors. Motors that power motor-operated valves are not included within the scope of this standard (they are the subject of IEEE Std 382-1985, IEEE Standard for Qualification for Actuators for Power Operated Valve Assemblies with Safety-Related Functions for Nuclear Power Plants).

The end result of the qualification process defined by this standard is documented evidence that the qualified motor can perform the intended safety function after service for a period of time or operating history (e.g., qualified life) and exposure to the applicable design basis event(s).

The realization of the projected qualified life usually requires a joint effort by the manufacturer and the user. The manufacturer is responsible for the design and production of the equipment. In order to support the qualification of the equipment, the manufacturer must provide and maintain documentation showing that it is capable of meeting specified performance requirements in specified service conditions throughout its qualified life.

The documentation must also show that the equipment is capable of performing its safety function during and, if required, for a specified time after exposure to a DBE, which might occur at any time during the life of the equipment. In order to satisfy this latter requirement, the manufacturers of the motor and the driven equipment shall be consulted to provide guidance on the proper application, handling, storage, installation, and maintenance of the equipment. The maintenance guidance must include identification of components and materials (e.g., bearings, lubricants, etc.) whose long-term characteristics are such that replacement or refurbishment is required in order to achieve the full qualified life. The user is responsible for identifying the application of the specifically requested Class 1E equipment and components. The user must specify service conditions and the safety-related performance requirements. The qualification program, for the connection between the motor and the incoming power cables is usually achieved separate from the qualification of the motor. Where the user requires inclusion of this interface in the qualification, specific requirements should be defined to the manufacturer.

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The user is responsible for proper application, handling, storage, installation, and maintenance in accordance with the guidance provided by the manufacturer.

Whenever these traditional roles are altered or supported by intermediate organizations, such as commercial grade dedication service organizations or users that establish qualifications independent of the manufacturer, the responsibilities for meeting the requirements of the standard must be established to ensure the proper design, manufacture, application, handling, installation, operation and maintenance of motors supplied for service remain consistent with the motor design for which qualification has been established.

This document presents specific procedures and criteria applicable to qualification of motors to the criteria described in IEEE Std 323-1983. Adherence to this standard alone may not assure public health and safety because it is the integrated performance of the structures, fluid systems, instrumentation systems, and electrical systems of the station that limits the consequence of accidents. Each user is responsible for assuring that this standard, if used, is pertinent to his or her application.

This revision of this document was prepared by a Working Group of Subcommittee 2 (Equipment Qualification) of the Nuclear Power Engineering Committee. The members of the Working Group were as follows:

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IEEE Standard for Qualifying Continuous Duty Class 1E Motors for Nuclear Power Generating Stations

1. Scope and purpose

1.1 Scope

This document describes the methods and requirements for qualifying continuous duty Class 1E motors for use in nuclear power generating stations. The requirements presented include the principles, procedures, and methods of qualification as they relate to continuous duty Class 1E polyphase squirrel cage ac motors. Other types of ac motors and dc motors may use techniques from this document, as applicable, in combination with basic qualification techniques from IEEE Std 323-1983.[1] Compliance with this document meets the requirements of IEEE Std 323-1983 as applied to Class 1E continuous duty motors.

The methods described shall be used for qualifying motors, extending the qualification, and updating the qualification if the motor's design of specified service conditions is modified. Other IEEE and industry documents presenting qualification methods for specific components within the motor and dealing with parts of the qualification program may be used, as applicable, to supplement this document. References are made within this document to applicable standards that provide guidance.

1.2 Purpose

The purpose of this document is to provide specific direction for the implementation of the requirements of IEEE Std 323-1983 as they apply to the specific features of continuous duty Class 1E motor qualification.

[1]Information on references can be found in clause 2.

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2. References

This standard shall be used in conjunction with the following standards.

ANSI/AFBMA 9-1990, Load Ratings and Fatigue Life for Ball Bearings.[2]

ANSI/AFBMA 11-1990, Load Ratings and Fatigue Life for Roller Bearings.

IEEE Std 100-1992, The New IEEE Standard Dictionary of Electrical and Electronics Terms (ANSI).[3]

IEEE Std 101-1987, IEEE Guide for the Statistical Analysis of Thermal Life Test Data.[4]

IEEE Std 112-1991, IEEE Standard Test Procedure for Polyphase Induction Motors and Generators (ANSI).

IEEE Std 117-1974, IEEE Standard Test Procedure for Evaluation of Systems of Insulating Materials for Random-Wound AC Electric Machinery (ANSI).

IEEE Std 275-1992, IEEE Recommended Practice for Thermal Evaluation of Insulation Systems for Alternating-Current Electric Machinery Employing Form-Wound Preinsulated Slator Coils for Machines Rated 6900 V and Below (ANSI).

IEEE Std 323-1983, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations (ANSI).

IEEE Std 344-1987, IEEE Recommended Practices for Seismic Qualifications of Class 1E Equipment for Nuclear Power Generating Stations (ANSI).

IEEE Std 429-1972, IEEE Standard Test Procedure for the Evaluation of Sealed Insulation Systems for AC Electric Machinery Employing Form Wound Slator Coils.[5]

IEEE Std 627-1980, IEEE Standard for Design Qualification of Safety Systems Equipment Used in Nuclear Power Generating Stations (ANSI).

NEMA MG-1-1987, Motors and Generators.[6]

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[2]ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

[3]IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[4]IEEE Std 101-1987 has been withdrawn; however, copies can be obtained from the IEEE Standards Department, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[5]IEEE Std 429-1972 has been withdrawn; however, copies can be obtained from the IEEE Standards Department, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

[6]NEMA publications are available from the National Electrical Manufacturers Association, 2101 L Street NW, Washington, DC 20037, USA.

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3. Definitions

The definitions to key terms used in this standard can be found in IEEE Std 100-1992 or IEEE Std 323-1983.

3.1 components: Items from which the equipment is assembled. (For motors, typical components include slator coils, rotor bars, bearings, bolts, capacitors, internal thermal overload relays, connectors, instrument sensors, locking devices, seals, sight glasses, springs, switches, etc.)

3.2 continuous duty: Operation at a substantially constant load for an indefinitely long time. (For motors, the constant load is to be within the nameplate rating of the motor.)

3.3 interface: A junction or junctions between a Class 1E equipment and another equipment or device. (For motors, typical interfaces include, as applicable: mechanical mounting connection to the driven equipment and the motor mounting to its base, any force transmitted to the motor, electrical connection, cooling system connections, and lubrication system connection.)

4. Overview

It is required that Class 1E motors,[7] with their interfaces, meet or exceed the specified performance requirement throughout their installed life. This is accomplished through a program that includes but is not limited to, design, qualification, production quality control, shipping, storage, installation, operation, maintenance, periodic testing, and surveillance. This document deals with the qualification portion of the program. This document discusses the need for maintenance, repair, and surveillance of motors to maintain qualification of motors throughout their installed life. All steps of the program require strict quality assurance—to assure that a manufactured motor of the same type (materials and manufacturing processes) matches that which was qualified and is suitably applied, installed, operated, maintained, and periodically tested.

The primary role of qualification is to provide assurance that Class 1E motors can perform their specified safety functions and that no failure mechanisms exist that can lead to a common cause failure under the postulated service conditions.

Motors exhibit aging mechanisms in their insulation systems. For this reason, the following shall apply:

a) For motors subject to harsh environments with significant aging mechanisms, an insulation system qualified life shall be established in accordance with this standard.

b) For motors located in mild environments and having no significant aging mechanisms, a qualified life shall not be required. Qualification in accordance with this standard shall provide adequate consideration of aging prior to a seismic event.

Wear and aging mechanisms also exist for bearings and lubrication. This standard sets forth requirements to define replacement and maintenance intervals that consider the manufacturer's recommendations and are based on actual service and operating conditions.

For all qualification programs, the result shall provide documentation demonstrating the motor's adequacy to perform its safety function(s). The documentation shall be in a form that allows verification by competent personnel.

The principles of this standard also should be applied to modified or refurbished motors.

[7]Throughout this standard, qualification of "motors" includes addressing their interfaces as part of the qualification program. When a motor interface includes an ASME component, qualification to the appropriate ASME Code is outside the scope of this document. See IEEE Std 627-1980.

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5. Qualification methods

The methods for qualifying motors are described below in 5.1–5.4.

5.1 Type testing

Type testing of motors satisfies qualification if it accounts for significant aging mechanisms, subjects the motor to specified service conditions, and demonstrates that such equipment subsequently can perform its intended safety function(s) for a minimum of the required operating time.

5.2 Operating experience

Data from motors of similar generic design that have successfully operated under known service conditions may be used as the basis for qualifying other motors to equal or less severe service conditions. The validity of this qualification method depends on the adequacy of documentation establishing the past service conditions, performance, maintenance, and similarity between the motors to be qualified, for which the operating experience exists. The operating experience may provide information on extrapolation of aging characteristics, failure modes, and failure rates.

5.3 Analysis

Qualification by analysis requires a logical assessment or a valid mathematical model of the motor to be qualified. Qualification shall consist of quantitative analysis supported by test data, operating experience analysis supported by test data, and operating experience or physical laws of nature to demonstrate that the motor can perform its safety function(s) under specified service conditions. Aging effects shall be considered.

The analysis, including logical bases and data supporting it, shall be presented in a step-by-step manner for one complete set of computations so that a person reasonably skilled in this type of analysis can follow the reasoning and computations.

5.4 Combined methods

Motors may be qualified by any combination(s) of type test, operating experience, and analysis. Testing of components supplemented by analysis may be used in the qualification process.

6. Qualification procedures

The method of qualification for motors in either a mild or harsh environment is based on a complete motor specification from which a qualification program can be formulated and implemented.

6.1 Specification requirements

A motor specification shall clearly define the safety function(s) of the motor and the service conditions during which the functions are required. As a minimum, the items in 6.1.1–6.1.3 shall be included.

6.1.1 Qualified life objective

For harsh environments, a qualified life objective shall be stated.

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6.1.2 Service conditions

Service conditions shall include normal, abnormal, and accident conditions. Nominal values and their expected durations, as well as the extremes—including design basis accident (DBA) conditions and their expected durations—are required to establish the qualification program. In addition to the typical service conditions detailed in IEEE Std 323-1983, service conditions specific to motors include, but are not limited to, the following:

a) Starting and operating requirements
b) Operating and non-operating times, including duty cycle description
c) Supply voltage and frequency values, including transient and steady state extremes
d) Driven equipment load requirements over the life of the motor
e) Normal and abnormal temperature and relative humidity
f) Normal and accident radiation
g) Steam temperature, pressure, and relative humidity (DBA)
h) Chemical spray
i) Submergence
j) Other adverse environments
k) Seismic and non-seismic vibration
l) Electrical, mechanical, and structural interfaces

6.1.3 Motor performance

The motor qualification program shall demonstrate that the motor is able to start, accelerate, and operate under all specified combinations of driven equipment load and speed variations and environmental conditions.

This program shall consider all specified combinations of the motor's station power system supply or the motor's variable speed control supply voltage and frequency variation.

The qualification program shall assure adequate motor torque at the extremes for these conditions. This may be determined by a combination of motor performance testing and calculations.

6.2 Qualification requirements in mild environments

Motors have a long standing history of reliable operation in non-nuclear electrical utilities when conservatively applied in mild environments. This history includes reliable operation during earthquakes [B5].[8] The critical design features for ensuring seismic ruggedness are to ensure that

a) The driven equipment and motor alignment is maintained.
b) The driven equipment and motor alignment are rigidly connected through their base to prevent relative motion.
c) Intermediate flexible bases do not exist.
d) Adequate thrust load capacity exists.
e) Adequate coupling flexibility between driven equipment and the motor, when needed to account for load induced vibration, is provided [B5].

Inherent in a motor's design are features accounting for induced electrical magnetic stress, starting torque stress, and load variation stress. These features result in motors that, when properly applied and installed, are inherently rugged to seismic events. A motor's internal forces during normal operation are much greater than seismic forces. Thus, each time a motor is started and loaded, it experiences internal forces much greater than those experienced during a seismic event.

[8]The numbers in brackets preceded by the letter B correspond to those of the bibliography in clause 9.

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This standard recognizes these conditions and does not require an aging subprogram be performed as part of a qualification program for motors in a mild environment. However, the program shall include the following:

a) The motor shall have been designed, manufactured, and tested to applicable industry standards. See 6.6 and IEEE Std 117-1974, IEEE Std 275-1992, IEEE Std 429-1972, IEEE Std 112-1991, ANSI/AFBMA 9-1990, ANSI/AFBMA 11-1990, and NEMA MG-1-1987.

b) Seismic withstand demonstration (see 6.13).

c) The motor shall, conservatively, be designed, applied, operated, and maintained to meet all service conditions (such as, variations in power supply, load inertia, horsepower, motor bearing loads, etc.).

6.3 Qualification requirements in harsh environments

For motors in harsh environments, qualification shall be based on tests, or a combination of tests, and analysis supported by tests. Testing may include both standard industry tests and tests specific to the purpose of motor qualification. Motor applications in harsh environments containing only one environmental parameter threat (e.g., radiation only) may be addressed adequately through an analytical technique (see 6.7). As environments become more severe, or as they increasingly consist of combinations of environments that can cause synergistic effects on the motor, it is expected that type-testing specific to the environments is utilized. Clauses 6.7–6.13 provide guidance on analytical techniques that may be used to supplement type testing.

The purpose of type testing is to demonstrate that the equipment offered for service, when aged to the end of its installed life, is capable of surviving the worst case design-basis event to which it is exposed—and shall remain operable or not fail. This may require demonstration of operability under load, both during and following the event, to assure performance of the equipment’s safety functions.

6.3.1 Type test plan

A type test plan shall be developed. Refer to IEEE Std 323-1983, 6.3.1.1.

6.3.2 Type test model

This standard requires that the type test model be a full-size motor or a scale model of a full-size motor that incorporates the essential components (insulation system, winding type, processes, bearings, seals, lead seals, and other essential accessory devices and equipment) used in production equipment. Any subsequent test designed to supplement the basic qualification program may be done on components or models of appropriate portions of the motor. The qualification tests should simulate, as closely as practical, all design-basis events that can affect the operation of any of these essential components. The test motor and accessory equipment should be a representative model—in that the design features and materials shall be identical to, and the operating stresses and loads shall be no less severe than, those for motors of the same type. If a test model differs from the motor to be installed, qualification reports shall both identify all materials, processes, and features not specifically representative of the installed motor, and justify any differences.

NOTE—The recommended method for simulating the dynamic loads placed on the motor by the driven equipment is to perform the qualification test with the motor connected to driven equipment of identical or similar design (to the equipment the motor will drive when in service). For situations in which it is not practical to use the actual driven equipment as a load, the load is to be simulated as closely as possible.

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6.3.3 Type test sequence

The recommended sequence for type testing is as follows:

1) Inspection of the test sample to verify its correctness and condition.
2) Functional test of the sample to establish base line performance. Sufficient data shall be taken to verify operability under load at the extremes of the power source (as appropriate). A functional test also is recommended after steps 3)–7), and 9). Refer to IEEE Std 112-1991.
3) Thermal aging of the test sample insulation where the insulation has a significant aging mechanism and qualified life is necessary [see 6.3.4.1, steps 1)–5)].
4) Mechanical aging of the test sample insulation [see 6.3.4.1, step 6)].
5) Irradiation of the test sample (normal and accident effects, as appropriate). Irradiation of the test sample to normal effects may be required before step 3) if dose rate effects are significant [see 6.3.4.1, step 7) and 6.7].
6) Voltage stress aging [see 6.3.4.1, step 8)].
7) Seismic withstand demonstration, as appropriate (see 6.3.5).
8) Design basis accident testing, as appropriate (see 6.3.6).
9) Post design basis accident testing, as appropriate (see 6.3.7).
10) Review test results and acceptance criteria to determine whether qualification objectives have been met (see 6.3.8).

Other test steps and sequences are acceptable when justified. All steps in the sequence shall be performed on the same test sample.

6.3.4 Normal service conditioning

Normal service is the portion of the motor operation accounting for the aging effects of the motor, from the time of initial installation until the motor is required (under design basis event conditions) to perform its safety function(s). Normal service represents the day-to-day operation of the motor (if it performs a function during the routine operation of the plant) during this time period. When the motor exists in a stand-by mode, with exercise periods, normal service is intended to represent the aging effects of this level of service. All, or portions of, the accelerated aging of the insulation system in 6.3.4.1 and other motor components in 6.3.4.2 (where significant aging exists), may be replaced by a naturally aged motor with a well-documented service history (including operation, maintenance, and environmental condition) that meets or exceeds the motor's operational requirements (see clause 5).

When components of the motor have no known aging mechanisms, further aging consideration for those components is not required. For example, metallic components are not subject to radiation aging or thermal aging considerations. These procedures age the motor to the end of installed life condition and represent normal service operation prior to design basis event and post-event simulation exposures.

6.3.4.1 Insulation conditioning

Stators, components, or insulation system models and interfaces shall be aged to account for the effects expected to accrue during the installed life of a motor. The aging procedure, where required, shall account for the effects of environment (atmosphere, temperature, humidity, radiation, and contaminants), voltage stress, and mechanical stresses (starting forces, vibration, and driven load). Prior to the type test, those components subject to degradation by the normal environment shall be aged to the equivalent of the installed life. The following procedure for thermal aging of the insulation system for normal service is suggested.

1) Identify an implied average-life characteristic for the insulation system of the motor through use of the motorette or formette test procedure in combination with IEEE Std 117-1974, IEEE Std 275-1992, or IEEE Std 429-1972. This should be a straight line on a graph, with an ordinate of log-scale time and an abscissa of reciprocal absolute temperature scale (see IEEE Std 101-1972).

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2) Identify the expected maximum insulation temperature of the motor, as follows: A representative motor shall be operated at the specified steady state load (not necessarily the rated or nameplate load) until thermal equilibrium is reached. The maximum temperature measured shall be corrected and extrapolated to reflect specified operating conditions and load profiles. These corrections account for differences (such as between test and operating ambient temperature, conversion of rise measurement by resistance to hot spot temperature) and variations in motor loading. This temperature test shall be in accordance with IEEE Std 112-1984.

3) Plot the motor's expected maximum insulation temperature and the desired lifetime as a point on the graph.

4) Draw a line through the temperature/lifetime point, parallel to the implied average life characteristic. Identify this line as the implied average aging characteristic. The intersection of this line and the desired accelerated aging time is the aging temperature.

5) Age the stator or insulation system model at this temperature for the required number of hours.

NOTE—Based on the present state of technology, this procedure is recommended as the most widely accepted practice. However, it is recognized that this procedure implies extrapolation possibly exceeding that permitted in IEEE Std 117-1974, IEEE Std 275-1992, and IEEE Std 429-1972; and does not determine absolute insulation life.

6) Following thermal aging, mechanically age the stator or insulation system model by vibrating the model for 1 h at 1.5 times the acceleration of gravity, as described in IEEE Std 117-1974, IEEE Std 275-1992, or IEEE Std 429-1972.

7) Following mechanical aging, radiation aging shall be done in accordance with 6.7.

8) Following all the aging steps (above), the stator or insulation system model shall be given a voltage stress. This stress shall consist of a high potential test of two-thirds of the sum of twice rated voltage plus 1000 Vac, for 1 min.

6.3.4.2 Lubricant, bearings, and seal components

Lubricant, bearings, and metallic seal components cannot be brought to a near end of installed life condition by accelerated aging simulation (refer to 6.9, 6.10, and 6.11). However, every effort should be made to simulate realistic conditions prior to a full-term type test—including the use of irradiated lubricants for motors that will be exposed to radiation prior to, or during, an accident.

Nonmetallic seals with safety functions shall be thermally aged and irradiated as part of the conditioning program.

6.3.5 Seismic

Seismic testing, when done as a part of the type test, shall be done prior to the DBA test (refer to 6.13).

6.3.6 Design basis accident environment simulation (DBA)

The test is designed to demonstrate the ability of a motor to withstand a design basis event environment. This is usually a loss-of-coolant accident (LOCA) simulation. Other harsh environmental transients, such as high energy line break (HELB), may require a similar test based on the detailed environmental conditions resulting from that DBE.

The environmental conditions to be simulated for light water reactor design basis events resulting from a postulated LOCA generally consist of exposure to steam and a spray or jet of water (including chemical solution) or other fluids. These environmental conditions differ markedly among different types of reactors, and also vary significantly from location to location in the plant. There may be locations outside the containment where special harsh environmental conditions exist.

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If equipment is to be qualified for more than one environment, test conditions may be chosen to envelop the specified environmental conditions of each environment. Likewise, the aged test motor may be exposed to each DBA environment, for which qualification is desired, by a series of separate exposures.

The following are suggested accident environment simulation conditions for a motor to be qualified for LOCA service (i.e., inside containment) in either a boiling water reactor or a pressurized water reactor plant.

1) Each sample motor and its accessory equipment that will be a part of the installed motor assembly shall be preconditioned as described in 6.3.4 and 6.3.5, including accident radiation, and operated to simulate its installed function.
2) For motors not in service at the initiation of a DBA, the test shall commence with the motor idle and at a cool temperature (<122 °F or 50 °C). Motors that may be in operational service at the initiation of the DBA shall be at the normal operating temperature produced by the motor's application.
3) Inject steam and chemicals into the chamber, as required, to simulate the first hours of the design basis accident conditions of containment steam environment.
4) During this time period, operate the motor at full load and rated voltage, starting after steam injection. Variation from required operating conditions, including minimum voltage and frequency starting and running conditions, may be demonstrated, where applicable, by analysis based upon motor base line test data.
5) After 3 h into the accident profile, stop the motor for 5 min and then restart the motor.
6) After an additional 1 h, stop the motor and reduce the pressure (in a time period of 15–120 min) to the level of atmospheric pressure. Cool the motor until its temperature is ≤122 °F (50 °C). Separate ventilation or no-load operation of the motor may be used to facilitate cooling.
7) For the second environmental transient, repeat steps 3)–5). This step may be eliminated if additional margin has been added to the first transient, in accordance with IEEE Std 323-1983.
8) Continue the temperature and pressure, according to the environmental requirements, and continue the post event exposures as described in 6.3.7.

6.3.7 Post design basis accident qualification

The accident simulation shall include testing a motor for a period of time equivalent to the duration following the DBE for which motor safety functions are required. During this test, the motor shall be operated to simulate its specified requirements during the post-event period, including stopping, starting, or continuous operation. Voltage and frequency variations may be considered by analysis. The duration of this test shall equal the post-event service period, including margin.

6.3.8 Inspection and analysis of test specimen

The test specimen shall be inspected and the condition of features important to performing the safety function shall be reported.

6.3.9 Acceptance criteria-test results analysis

A motor or motor component shall be considered to be qualified if the motor or motor component performs its specified function throughout its test program.

6.4 Maintenance of qualification

The requirements for maintaining qualification during shipment, storage, installation, operation, maintenance, and surveillance of the motor shall be documented in accordance with clause 8. The requirements shall address any maintenance performed, or configurations used, during qualification testing.

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6.5 Margin

Application of margin shall be in accordance with IEEE Std 323-1983, 6.3.1.5.

6.6 Winding insulation endurance determination (thermal, humidity, vibration and voltage stress)

The thermal winding endurance qualification of the insulation system shall be obtained by following the procedures in IEEE Std 101-1987, IEEE Std 117-1974, or IEEE Std 275-1992; or for both mild and harsh environmental qualification, IEEE Std 429-1972.

For motors in harsh environment applications, extrapolation of the obtained regression life-temperature curve shall be extended to the installed life. To allow for operation though ambient temperatures and postulated exposures, the temperature intercept shall be equal to, or greater than, the maximum temperature of the motor, as determined in IEEE Std 323-1983, 6.3.4.1.

For motors in mild environment applications, insulation class ratings based on the above industry standards are available.

6.7 Radiation endurance

Some materials degrade rapidly in radiation while others maintain their properties after high integrated dosage levels.

6.7.1 Negligible radiation levels

Considering the nature of materials used in the manufacture of motors, any level of integrated radiation dosage up to, and including, 10^4 rads is considered negligible [B2]. No radiation qualification data need be provided for integrated radiation dosages up to, and including, 10^4 rads.

6.7.2 Significant radiation levels

For radiation levels in excess of 10^4 rads, radiation qualification shall be required. If nuclear radiation exposure tests and analysis of the various materials used in the motor show that at the design basis levels, direct damage to any materials or the evolution of radiation produced substances are negligible, then actual radiation exposure to the test motor is not necessary as part of the qualification. Otherwise, a radiation test shall be conducted. Known combined effects that may be produced by the nuclear radiation exposure acting in concert with other environmental exposures shall be considered.

Dose rate effects should be considered. For additional radiation effects data—which is important during material selection and evaluation—see ANSI/AFBMA 11-1990 and [B2].

6.8 Motor lead cable

A motor lead cable connects the motor windings to their external connection point. The motor lead cable shall be qualified, as required by the application, using the techniques in IEEE Std 323-1983.

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6.9 Bearings

6.9.1 Anti-friction bearings

Anti-friction bearings shall be sized for long life in accordance with the following standards:

Ball bearings—ANSI/AFBMA 9-1990
Roller bearings—ANSI/AFBMA 11-1990

The time-related failure characteristics of an anti-friction bearing are such that when the number of failures versus the hours of operation is plotted, the result is a normal distribution curve. Due to the statistical nature of this relationship, anti-friction bearing failure does not represent a common cause failure. To meet the qualified life objective of the motor, maintenance and replacement of bearings should be based on the motor's operational schedule, service conditions, and surveillance.

6.9.2 Sleeve and sliding bearings

The life of sleeve bearings or other sliding bearings is dependent on lubricants, temperature, and contaminants. To meet the qualified life objective of the motor sleeve bearing, replacement shall be based on observation of wear patterns during maintenance or the manufacturer's recommendations.

6.10 Lubricant

Lubricants should be chosen based on the thermal, radiation, and other environmental requirements of each application. To maintain motor qualification, lubricants shall be replenished or changed in accordance with the recommended replenishment schedule and instructions. Replenishment schedules and instructions shall be justified and documented.

When a lubricant to be used in the motor is different, by manufacture or specification, from the lubricant used in the qualification program, the new lubricant shall be qualified. When two lubricants are mixed, the combined characteristics may not be similar to those of either component and the mixture shall be qualified. For additional information on qualification techniques for evaluating the adequacy of substitute lubricants, see [B2] and [B3].

6.11 Seals and gaskets

6.11.1 Rotating seals

Seals are designed to inhibit the entrance of foreign matter between fixed and rotating members of the motor. They may be either the contact or non-contact type. Where the seal is required to assure the motor can perform its safety function, a qualification program addressing the safety function shall be developed for the seal.

Nonmetallic materials used in seals performing safety functions shall be evaluated for thermal and radiation aging characteristics and chosen to meet the requirements of 6.7.

6.11.2 Gaskets

Generally, gaskets do not perform safety functions in motors. However, when gaskets do perform safety functions in motors, gasket materials shall be evaluated for thermal and radiation aging characteristics and chosen to meet the requirements of 6.7.

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6.12 Accessories

Most motor accessories, such as space heaters, temperature detectors, and vibration detectors, are normally used to monitor or maintain proper motor condition. However, the failure of such a device generally has no direct impact on the ability of the motor to perform its required function. Each accessory device, as a minimum, shall be analyzed to demonstrate that its failure modes shall not affect operation of the motor. Accessories that are required to perform or support a safety function shall be included in the qualification program. For example, when a motor is provided with an enclosure drain feature to prevent accumulation of potential condensation (features such as this are required for qualification), this feature(s) shall be identified clearly and the qualified configuration(s) shall be specified clearly.

6.13 Seismic

Seismic qualification shall be performed for Class 1E motors and any accessory equipment whose failure could affect the motor's ability to perform its intended safety functions. The requirements of IEEE Std 344-1987 shall be met for the seismic qualifications of Class 1E motors and their accessory equipment as defined in the motor's specification (see 6.1). The guidelines presented in this document are intended to supplement and amplify the practices of IEEE Std 344-1987 as they apply to motors. Refer to IEEE Std 344-1987 for definitions and general seismic qualification practices. Seismic qualification may be applied to individual motors, or to a class of motors with similar design, providing the basis for qualification by similarity is justified.

6.13.1 The seismic design basis event

The postulated seismic events, as defined in the specification, shall be used to define the seismic environment for the motor(s) location(s). Generic requirements may be postulated to envelop the range of environments expected in multiple locations within a single station or a defined group of stations.

6.13.2 Safety functions

Each motor's application shall be analyzed to determine the required safety functions. The motor constituent parts, including its accessories, shall be analyzed to determine those elements contributing to the motor's ability to perform the required safety functions. Qualification shall be addressed only for safety functions.

Safety functions shall be reviewed to determine if they are to be verified both during and following the seismic DBE, or only following the seismic DBE. The required safety functions' duration of operation both during and following the seismic DBE also shall be addressed in the seismic qualification. A generic qualification plan shall envelop all safety functions of the multiple applications.

6.13.3 Equipment boundary and interfaces

A motors interfaces with driven equipment. A motor's accessory equipment may connect to power or fluid supplies. The motor's boundary shall be defined in the specifications. The effects of operating the motor and the seismic forces crossing the motor's boundary shall be accounted for in the seismic qualification. The ability of the motor's interfaces to retain structural and functional integrity, as required by the determination of the safety function in 6.1, shall be demonstrated.

The seismic ground motion may be filtered and amplified by intervening building and support structure (such as, a vertical pump supporting a motor). The motor's specification shall detail any intervening or support structure that shall be considered to obtain amplified seismic spectra to the motor.

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7. Simulated test profiles

The qualification specification shall furnish sufficient environmental data to allow the simulation of the postulated environment service conditions profile for the motor being qualified (see 6.1.2).

8. Documentation

8.1 General

The purpose of documentation is to provide evidence that Class 1E motors are qualified for their specific applications and meet their specified criteria. Documentation shall include data pertinent to the qualified design and shall be arranged in a clear, logical, and auditable form. The qualification report shall identify all aging mechanisms considered during the qualification of the motor assembly. Evidence shall be presented to show that all qualification requirements are satisfied, the methods chosen to qualify the motors are fully justified, and the motor's qualified life is established.

Any failures or anomalies occurring during testing shall be documented—both in terms of their cause and the overall effects on the motor's qualification. The documentation shall indicate whether analysis showed the failure to be of random or common cause. If common cause, the documentation shall indicate the corrective action that was taken (material change or replacement schedule).

8.2 Documentation files

The motor qualification specification shall define the qualified life objective, service conditions, and interfaces as covered in 6.1.1–6.1.3.

The qualification report shall describe the qualification program and various design codes and standards used in the qualification program. The content of the report is dependent on both the qualification method used and the motor's required operating environment (mild or harsh)—and is covered in 8.3 and 8.4.

In addition to the environment-specific documentation of 8.3 and 8.4, generic documentation shall include the following items:

a) Identification of the motors by manufacturer's nameplate data.
b) Reference to the specification (see 6.1).
c) Identification of the accessory equipment and its safety function(s) for each motor.
d) Description of the qualification methods, including all assumptions made with regard to the qualification of any component not specifically addressed in the individual phases of the qualification program.
e) Identification of any shipping requirements, scheduled preventative maintenance, installation requirements, interface requirements, periodic testing, inspection, surveillance, and parts replacement required to maintain motor qualification.

8.3 Documentation requirements for mild environment

The qualification report for motors in a mild environment shall contain the following information:

a) Demonstration that the motor has been designed, manufactured, and tested to industry IEEE and NEMA standards, as applicable. (See clause 2.)
b) Seismic qualification, as specified in 6.13.

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c) Objective evidence demonstrating that the motor meets all of the safety function performance objectives of the specification.
d) Data on the bearing and lubricant maintenance and replacement schedule required to maintain the motor qualification.

8.4 Documentation requirements for harsh environment

The qualification report for motors in a harsh environment (see 6.3) shall contain information on the type test and any supporting analysis (as applicable).

8.4.1 Type test plan

Refer to IEEE Std 323-1983, 6.3.1.1.

8.4.2 Age conditioning

8.4.2.1 Normal service qualification

Data shall be recorded as follows:

a) Data stating the insulation temperature of the motor. This data shall reflect all the estimated operating times and temperatures during the motor's normal service life.
b) Insulation life curves taken in accordance with procedures of 6.3.4.1, item 1).
c) Radiation data for all materials in the motor sensitive to significant radiation levels, when applicable (refer to 6.7).
d) Motor lead-cable aging data.
e) Data on bearing and lubricant maintenance and replacement schedule required to maintain the motor qualification. For applications with significant radiation levels, data shall be recorded regarding lubricant suitability in radiation.
f) Data on maintenance or replacement schedule of gaskets and seals required to maintain motor qualification. For applications with significant radiation levels, data shall be provided regarding seal and gasket suitability in radiation.
g) Results of failure mode analysis for motor accessories not directly affecting the motor's function.
h) Qualification data for any motor accessories affecting the motor's safety function.
i) Seismic report.

8.4.2.2 Normal service conditioning procedure

Refer to 6.3.4.

8.4.3 Report of test results

Data shall include the following:

a) Objective of test
b) Detailed description of test sample
c) Description of test setup, instrumentation data, and calibration data
d) Test procedure
e) Maintenance requirements to preserve the motor qualification
f) Summary of test data and accuracy

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8.4.4 Summary and conclusions

Data shall include limitations, resolution of anomalies, and qualified life determination.

8.4.5 Approval signature

The person or persons responsible for the motor qualification shall sign and date the report.

8.4.6 Report format

It is suggested that the sequence for the body of the overall qualification report be in the sequence of 8.4.1-8.4.3.

8.5 Documentation requirements for analysis used to support mild and harsh environment qualification

The analysis shall include the following:

a) Identification of the item being analyzed.
b) Specific safety function(s), postulated failure modes, or the failure effects to be demonstrated by analysis.
c) Description of the analytical methods, computer program, or mathematical model used and the method of verification.
d) Assumptions and empirically derived values used, with appropriate justification.
e) Maintenance requirements to preserve the motor qualification.
f) Conclusions, including summary of analytically established performance characteristics and their acceptability.
g) Approval signature and date.

9. Bibliography

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